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EFFECT OF HEAT TREATMENT UPON THE QUALITY OF DRY SKIM MILK AND CONDENSED SKIM MILK FOR ICE CREAM

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INTRODUCTION

In the manufacture of ice cream more dry skim milk is being used. Dry skim milk is a new form of milk solids used in ice-cream making, and was first used by the industry in appreciable quantities about 1917. The quantity of dry skim milk used annually in making ice cream, however, is small when compared with the quantity of milk solids obtained from sweetened and unsweetened condensed milk.

In a survey¹ recently made by the International Association of Ice Cream Manufacturers to ascertain the sources of serum solids used in ice cream it was found that 72.5 per cent was supplied by concentrated milk products. Condensed milk furnished 51.7 per cent, cream 12.3 per cent, and dry skim milk 8.5 per cent. This survey shows that of the 60.2 per cent of the serum solids obtained from concentrated milk products other than cream, only 8.5 per cent was derived from dry skim milk. (Figs. 1 and 2.)

In the present work comparisons have been made to determine whether there is a difference in quality of ice creams containing different types and forms of dry skim milk and ice creams containing the better form of spray-dried skim milk and unsweetened condensed milk when representing over 80 per cent of the serum solids.

¹ HIBBEN, R. C. WHERE DO SOLIDS COME FROM? Ice Cream Trade Jour. 24(6): 39-43, illus. 1928.

DAIRY PRODUCTS AND KINDS OF SUGAR USED IN THE MANUFACTURE OF ICE CREAM. ANALYSIS OF 1. DAIRY PRODUCTS AND INGREDIENTS. 2. SOURCE OF BUTTERFAT. 3. SOURCE OF MILK SOLIDS NOT FAT. 4. KINDS OF CONDENSED MILK. 5. KINDS OF SUGAR. Internatl. Assoc. Ice Cream Manfrs. [Spec. Bul.] 12 p., illus. 1928.

INTERNATIONAL ASSOCIATION OF ICE CREAM MANUFACTURERS. ABSTRACTS OF LITERATURE ON MANUFACTURE AND DISTRIBUTION OF ICE CREAM. APPENDIX. PRACTICAL FACTS AND STATISTICS FOR THE ICE CREAM MANUFACTURER. Compiled by the Bureau of Service and Statistics, International Association of Ice Cream Manufacturers. v. 2, p. 44-45, illus. Harrisburg, Pa. 1928. [Multigraphed.] [Appendix separately paged.]

It is well known that the colloidal properties (which depend largely on the degree of hydration of the casein particles) and the lactose flavors of milk solids in condensed milk, evaporated milk, and dry skim milk often vary, but it is not definitely known to what extent these variations are advantageous or detrimental to ice cream. The purpose of this investigation is to show the effect that some of these common variations in the character of the milk solids from different sources may have on the flavor and texture of medium-rich ice cream.

EVALUATION OF THE PROPERTIES OF SERUM SOLIDS IN ICE CREAM

In considering the sources of serum solids used in ice-cream making it is necessary to evaluate the contribution each source can make in improving the flavor and texture of the product. Since it is practically impossible to consider flavor and texture independently, the simplest

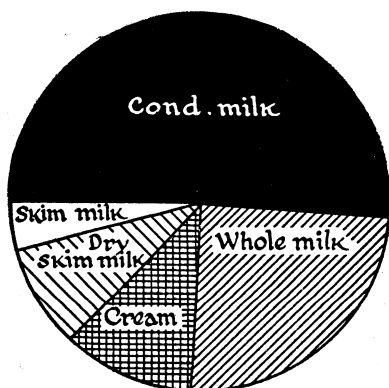


FIGURE 1.—Sources of milk solids not fat used in ice cream made by 331 manufacturers in the United States

(Courtesy International Association of Ice Cream Manufacturers)

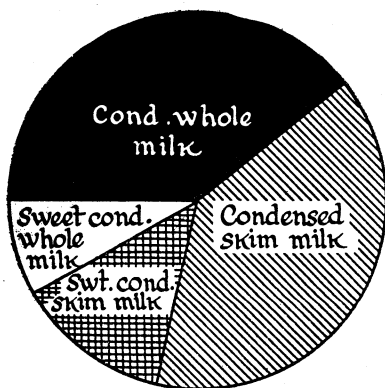


FIGURE 2.—Relative importance of different kinds of condensed milk which furnish the milk solids not fat in the ice cream made by 331 manufacturers in the United States

(Courtesy International Association of Ice Cream Manufacturers)

and best way to determine the relative value of two or more milk products in ice cream is to consider them together. An attempt has been made, therefore, to correlate the qualities of flavor and texture with variations in the viscosities of suspensions of various dry skim milks which had received different heat treatments prior to their desiccation. The flavor and texture of the ice creams made from both drum-dried and spray-dried skim milk have been evaluated by the sales-preference method.²

RELATION BETWEEN DIFFERENT TYPES AND FORMS OF DRY SKIM MILK IN ICE CREAM

Two distinct types of dry skim milk are used in the manufacture of ice cream, namely, spray dried and drum dried. The spray-dried product has a fine, smooth, velvety texture and is usually very soluble. The drum-dried product is coarser, more granular, and generally less

² In the sales-preference method, samples of two ice creams made from mixes differing in some respect are sold to from 30 to 50 unselected persons who eat the samples, compare them on the basis of both texture and flavor, and then express their preference.

soluble. There are also different characteristics that are not generally recognized in each type. In this experiment some of these characteristics have been studied in what may be termed two forms of spray-dried skim milks which were prepared under different heat treatments.

Grewe and Holm³ have shown that the body of the solution of a reconstituted spray-dried skim milk (fig. 3) is affected by the heat treatment of skim milk prior to desiccation. These investigators measured the viscosities of six dry milks which had been prepared from skim milk forewarmed at temperatures of 50°, 63°, 73°, 83°, 93°, and 100° C., respectively, and showed that there is a decrease in body (viscosity) with forewarming temperatures of 50°, 63°, and 73°, a marked increase at 83°, and again a slight decrease at 93° and 100°. On comparing the viscosity determination for the solution of reconstituted dry milk heated to 63°C. (145° F.), which is the common heat treatment used in forewarming prior to drying, with the maxi-

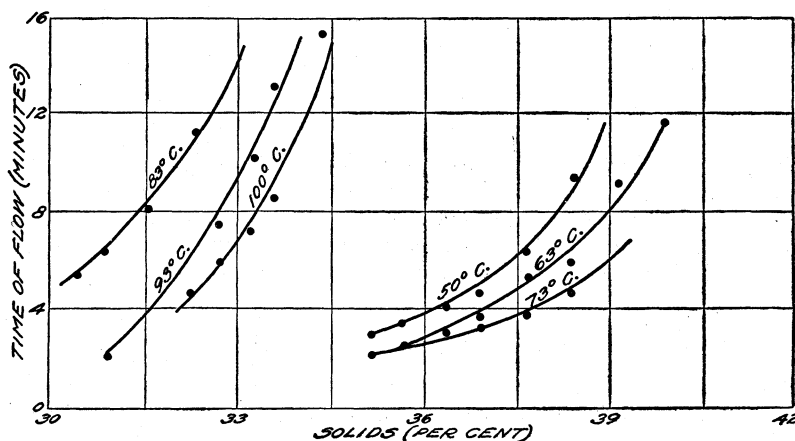


FIGURE 3.—Effect of forewarming of milk upon viscosity of the solution of reconstituted dry products. (From Grewe and Holm)

mum viscosity, obtained at a temperature of 83° C. (181° F.), it was found that these viscosities have a ratio of 5 to 4. This indicates that there was a greater hydration in the latter or, as shown in Figure 3, that a lower concentration was necessary to produce the same viscosity.

This difference in the hydration of these two dry milks produced by heating the milk during the forewarming process to the temperatures mentioned for 30 minutes results in what might be termed two different forms. These forms are designated herein as form A and form B, and for convenience are also referred to as spray A and spray B.

Since there are marked differences in the physical properties of spray-dried and drum-dried milks, and also in the different forms of each type, it is important to know which of these products is the more suitable ingredient for ice cream and which form of dry skim milk is more suitable.

³ GREWE, E., and HOLM, G. E. EFFECT OF VARIATION IN THE METHODS OF MANUFACTURE ON THE BAKING QUALITY OF DRY SKIM MILK. Cereal Chem. 5: 461-469, illus. 1928.

COMPARISON BETWEEN SPRAY A AND SPRAY B DRIED SKIM MILK

In a comparison of the effects of form A and form B spray-dried skim milk on the quality of ice cream, it was found (Table 1) that they produced a substantial difference in the flavor and texture of ice cream.

TABLE 1.—*Preferences for ice creams made from spray A and spray B dried skim milk*

Experiment No.	Number of testers	Number of preferences for ice cream prepared from—		Percentage of preference for—	
		Spray A milk (preheated at 63° C.)	Spray B milk (preheated at 83° C.)	Spray A milk (preheated at 63° C.)	Spray B milk (preheated at 83° C.)
1.....	33	17	16	51.5	48.5
2.....	30	8	22	26.7	73.3
3.....	42	14	28	33.3	66.7
Total.....	105	39	66	1 37.2	1 62.8

¹ Percentage of total preferences.

Three experiments with these two forms of spray-dried milk were made. The first did not show any marked difference in the quality of the two ice creams made for the test. No reason could be given for this. It was evident from the second and third experiments, however, that the spray B form of dry skim milk was much superior for ice cream.

COMPARISON OF SPRAY-DRIED AND DRUM-DRIED SKIM MILK

In a comparison of two different types of dry skim milk, spray B milk, prepared in the laboratory, and a well-known drum-dried milk, designated as drum 1 for the purpose of this experiment, the preference was in favor of the ice cream containing spray-dried milk. The relationship between these two dry milks is shown by the preference in Table 2.

TABLE 2.—*Preferences for ice creams made from spray B and a commercial drum-dried skim milk*

Experiment No.	Number of testers	Number of preferences for ice cream prepared from—		Percentage of preference for—	
		Spray B milk (preheated at 83° C.)	Drum 1 dried milk	Spray B milk (preheated at 83° C.)	Drum 1 dried milk
1.....	32	21	11	65.6	34.4
2.....	32	25	7	78.1	21.9
3.....	34	19	15	55.9	44.1
Total.....	98	65	33	1 66.3	1 33.7

¹ Percentage of total preferences.

In this 2-way comparison, which experience shows is the best and most reliable way to distinguish a difference in quality, the preference given by 98 testers in three experiments was 66.3 per cent, or 2 to 1, in favor of the ice cream made with spray B dried skim milk.

COMPARISON OF SPRAY A, SPRAY B, AND A DRUM-DRIED SKIM MILK

In a 3-way comparison of spray A, spray B, and another lot of drum-dried skim milk from the same manufacturer it was found that the flavor and texture produced by spray B dried milk were more desirable than those produced by either the drum 2 or spray A dried milks. The relation of these three dry milks to the flavor and texture of the ice cream is shown in Table 3 by the preference given for each ice cream.

TABLE 3.—*Preferences for ice creams made from spray A, spray B, and drum-dried skim milk*

Experiment No.	Number of testers	Number of preferences for ice cream prepared from—			Percentage of preference for—		
		Spray A milk (pre-heated at 63° C.)	Spray B milk (pre-heated at 83° C.)	Drum 2 dried milk	Spray A milk (pre-heated at 63° C.)	Spray B milk (pre-heated at 83° C.)	Drum 2 dried milk
1.....	28	5	13	10	17.9	46.4	35.7
2.....	27	5	20	2	18.6	74.0	7.4
3.....	28	5	15	8	17.8	53.6	28.6
Total.....	83	15	48	20	¹ 18.1	¹ 57.8	¹ 24.1

¹ Percentage of total preferences.

COMPARISON OF SPRAY-DRIED SKIM MILK WITH TWO COMMERCIAL BRANDS

The next series of experiments was to compare spray B dried milk with two well-known commercial brands of spray-dried skim milk. These brands were purchased in closed tin containers directly from the manufacturer, with the request that they be as fresh as possible, and each brand was used for the experiment within six weeks after it was received. In this experiment these brands are designated as brand X and brand Y. Three separate comparisons were made with each commercial brand of dried milk.

SPRAY B DRIED SKIM MILK AND BRAND X

The results of these three tests (Table 4) on the whole were in favor of the ice cream from spray B dried milk. Although one of the experiments (No. 2) did not show any appreciable difference in the flavor and texture of the two ice creams, there was an appreciable difference shown by the other two experiments.

TABLE 4.—*Preferences for ice creams made from spray B dried skim milk and brand X dried skim milk*

Experiment No.	Number of testers	Number of preferences for ice cream prepared from—		Percentage of preference for—	
		Spray B milk (pre-heated at 83° C.)	Brand X milk	Spray B milk (pre-heated at 83° C.)	Brand X milk
1.....	40	23	17	57.5	42.5
2.....	47	23	24	48.9	51.1
3.....	34	25	9	73.5	26.5
Total.....	121	71	50	1 58.7	1 41.3

¹ Percentage of total preferences.

SPRAY B DRIED SKIM MILK AND BRAND Y

In this test (Table 5) the preference from 133 individual comparisons was 66.9 per cent in favor of spray B dried milk.

TABLE 5.—*Preferences for ice creams made from spray B dried skim milk and brand Y dried skim milk*

Experiment No.	Number of testers	Number of preferences for ice cream prepared from—		Percentage of preference for—	
		Spray B milk (pre-heated at 83° C.)	Brand Y milk	Spray B milk (pre-heated at 83° C.)	Brand Y milk
1.....	53	29	24	54.7	45.3
2.....	40	30	10	75.0	25.0
3.....	40	30	10	75.0	25.0
Total.....	133	89	44	1 66.9	1 33.1

¹ Percentage of total preferences.

In this series of experiments the results of experiment No. 2 were overwhelmingly in favor of the spray B dried milk product, and similar results were obtained in experiment No. 3, which was made six weeks later.

DIFFERENCE IN QUALITY OF ICE CREAMS CONTAINING SPRAY B DRIED SKIM MILK AND UNSWEETENED CONDENSED SKIM MILK FOREWARMED AT 63° C.

The next question to be considered was the relative difference in quality of ice creams made from spray B dried skim milk and those made from unsweetened condensed skim milk. There is a feeling among ice-cream manufacturers that the most suitable form of concentrated serum solids generally comes from either sweetened or unsweetened condensed skim milk. Since a great majority of the manufacturers depend upon unsweetened condensed milk as the source of a large part of their serum solids, this product is the only one which has been compared with dried skim milk in this investigation. In these comparisons fresh condensed skim milk prepared in the laboratories of this bureau was used. It is assumed that this unsweetened condensed milk was comparable to the average quality of commercially made condensed skim milk.

In referring to the product known by the ice-cream industry as unsweetened condensed skim milk, hereafter in this circular it will be termed condensed skim milk for convenience and should not be confused with products known as evaporated or sweetened condensed milks.

Two sets of experiments were made, (1) a comparison of the effect of spray B dried skim milk and unsweetened condensed skim milk on the quality of ice cream; and (2) a comparison of the effects of spray A and spray B dried skim milk; and unsweetened condensed skim milk.

These two comparisons (Tables 6 and 7), representing an expression from 99 and 58 testers respectively, the preference was decidedly in favor of the ice cream made with spray B dried skim milk.

The following question is often seriously considered by many ice-cream manufacturers in planning their mixes: What form of concentrated milk will produce the best quality of ice cream? This question can not be answered from the data given in Tables 6 and 7, because, aside from dry milk, the only concentrated milk used was unsweetened condensed skim milk. The comparison of ice creams made from sweetened condensed and evaporated milk with those made from dry skim milk has not yet been made. More experimental evidence is necessary to show the general quality relationship of ice creams made from these two products.

TABLE 6.—*Preferences for ice creams made from spray B dried skim milk and unsweetened condensed skim milk*

Experiment No.	Number of testers	Number of preferences for ice cream prepared from—		Percentage of preference for—	
		Spray B dried skim milk (pre-heated at 83° C.)	Condensed skim milk	Spray B dried skim milk (pre-heated at 83° C.)	Condensed skim milk
1-----	36	24	12	66.7	33.3
2-----	30	19	11	63.3	36.7
3-----	33	26	7	78.8	21.2
Total-----	99	69	30	¹ 69.7	¹ 30.3

¹ Percentage of total preferences.

TABLE 7.—*Preferences for ice creams made from spray A, spray B, dried skim milk, and unsweetened condensed skim milk*

Experiment No.	Number of testers	Number of preferences for ice cream prepared from—			Percentage of preference for—		
		Spray A dried skim milk (pre-heated at 63° C.)	Spray B dried skim milk (pre-heated at 83° C.)	Condensed skim milk	Spray A dried skim milk (pre-heated at 63° C.)	Spray B dried skim milk (pre-heated at 83° C.)	Condensed skim milk
1-----	30	8	17	5	26.7	56.6	16.7
2-----	28	2	24	2	7.1	85.8	7.1
Total-----	58	10	41	7	17.2	¹ 70.7	¹ 12.1

¹ Percentage of total preferences.

DIFFERENCE IN QUALITY OF ICE CREAMS CONTAINING SPRAY B DRIED SKIM MILK AND UNSWEETENED CONDENSED SKIM MILK FOREWARMED AT 83° C.

The comparisons made so far with condensed skim milk have been made only with milks forewarmed in the hot wells at 63° C. (145° F.). The question might be asked, therefore, whether or not spray B dried skim milk would be as good or a better ingredient than unsweetened condensed skim milk if the latter were forewarmed at 83° C. (181° F.), as is done with spray B milk.

Four experiments were made to determine the difference in quality of ice cream made from spray B dried skim milk and ice cream made from unsweetened condensed milk. In a comparison of the effects of spray B dried skim milk and condensed skim milk forewarmed at 83° C., representing separately prepared lots of condensed skim milk and dry skim milk, the results (Table 8) of the first two and the fourth experiments indicated that there usually is an appreciable difference in the quality of the ice cream. The results of the third experiment did not show any difference in quality, but the results of the other three were in favor of the spray B dried skim milk. The difference in the palatability of the two products is shown by the fact that 63.47 per cent of the preferences were in favor of the ice cream made with spray B dried skim milk.

TABLE 8.—*Preferences for ice creams made from spray B dried skim milk and unsweetened condensed skim milk forewarmed at 83° C.*

Experiment No.	Number of testers	Number of preferences for ice cream prepared from—		Percentage of preference for—	
		Condensed skim milk preheated at 83° C.	Spray B dried skim milk (preheated at 83° C.)	Condensed skim milk preheated at 83° C.	Spray B dried skim milk (preheated at 83° C.)
1.....	44	8	36	18.19	18.81
2.....	58	24	34	41.38	58.62
3.....	53	27	26	50.94	49.06
4.....	52	17	35	32.70	67.30
Total.....	207	76	131	¹ 36.53	¹ 63.47

¹ Percentage of total preferences.

DIFFERENCE IN QUALITY OF ICE CREAMS CONTAINING SPRAY B DRIED SKIM MILK AND UNSWEETENED CONDENSED SKIM MILK SUPERHEATED AFTER CONDENSING

The practice of using superheated condensed skim milk—that is, milk which has been heated to about 90° C. (194° F.), and even to higher temperatures—is quite common in certain sections of the country, and the claim is often made that this form of condensed skim milk produces a better quality of ice cream than does the un-superheated product.

The relative qualities of ice cream made from superheated condensed skim milk and spray B dried skim milk are shown by two additional groups of experiments. A comparison between ice creams made from superheated and from ordinary condensed skim milk, both of which had been previously forewarmed at 63° C. prior to

condensing, shows (Table 9) that superheating is usually beneficial. Each of the four experiments represent separately prepared lots of condensed skim milk prepared by forewarming the milk to 63° and concentrating to about 3 to 1. Half of each lot was then superheated in a steam-jacketed kettle to from 90° to 93° C. for 10 minutes and then cooled. In this comparison the results of the first experiment did not show any appreciable difference in quality between the two ice creams. In the other three experiments the results were in favor of the ice cream made from superheated condensed skim milk. From the total results representing 183 individual comparisons, 62.3 per cent of the testers decided in favor of the ice cream made from superheated condensed skim milk.

TABLE 9.—*Preferences for ice creams made from unsweetened condensed skim milk forewarmed at 63° C. and unsweetened condensed skim milk superheated*

Experiment No.	Number of testers	Preferences for ice cream prepared from—		Percentage of preference for—	
		Condensed skim milk superheated	Condensed skim milk preheated at 63° C.	Condensed skim milk superheated	Condensed skim milk preheated at 63° C.
1.....	38	18	20	47.37	52.63
2.....	41	30	11	73.17	26.83
3.....	46	25	21	54.13	45.87
4.....	58	41	17	70.70	29.30
Total.....	183	114	69	¹ 62.30	¹ 37.70

¹ Percentage of total preference.

In another experiment (Table 10) four ice creams were made from four separate lots of spray B dried skim milk. These were compared with four ice creams made from four separate lots of condensed skim milk which were forewarmed at 63° C., concentrated to about 3 to 1, and superheated in the same manner as before. The preference was again in favor of the ice cream made from spray B dried skim milk.

TABLE 10.—*Preferences for ice creams made from spray B, dried skim milk, and unsweetened condensed skim milk superheated*

Experiment No.	Number of testers	Number of preferences for ice cream prepared from—		Percentage of preference for—	
		Condensed skim milk superheated	Spray B dried skim milk (preheated at 83° C.)	Condensed skim milk superheated	Spray B dried skim milk (preheated at 83° C.)
1.....	50	20	30	40.00	60.00
2.....	49	23	26	46.94	53.06
3.....	36	6	30	16.67	83.33
4.....	48	25	23	52.08	47.92
Total.....	183	74	109	¹ 40.44	¹ 59.56

¹ Percentage of total preference.

In this comparison the results of two of the four experiments were decidedly in favor of spray B dried skim milk, whereas the other two experiments indicated that there was only a slight difference in quality as between the ice creams made from the two products.

In the four experiments, totaling 183 individual comparisons, however, about 60 per cent of the testers expressed preference for the ice cream made from spray B dried skim milk.

In these three series of experiments (Tables 8, 9, and 10) it was the opinion of the majority of the testers that the ice cream made from spray B dried skim milk was as high in quality, and in some cases higher, than the ice cream made from condensed milk products.

SUMMARY

The sales-preference method of comparison used in these experiments is valuable as a practical means of distinguishing differences in physical properties of ice cream which can not be measured by chemical and physical determinations. Any attempt to evaluate the differences in flavor and texture of ice cream must always be based on the organoleptic effect plus the individual opinion regarding this effect, which are at best more or less variable and indefinite. As there is no laboratory method of determining the best flavor and best texture of ice cream, these comparisons which have to do with differences in both the flavor and texture are best measured by the sales-preference method. This method is not an absolute means of appraising the relative qualities of two different ice creams, but shows the tendency of the change produced by the variations in manufacture.

The results of these experiments indicate (1) that various milk solids not fat used in manufacture of ice cream differed in their ability to impart desirable properties to the ice cream; (2) that of the dried skim milks used in ice cream the most beneficial was the spray type, particularly the one in which the milk was preheated at 83° C. prior to drying; (3) that this dried skim milk was also a better ingredient for ice cream than the three forms of unsweetened condensed skim milks used; and (4) that condensed skim milk when superheated improved the quality of ice cream more than when it was not superheated or was forewarmed at 83° C., but did not improve the quality of ice cream as much as spray B dried skim milk.

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